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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO

GUIDANCE AND NAVIGATION

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E-1142 (Rev. 7)

(UNCLASSIFIED TITLE)

WEIGHT AND BALANCE
REPORT

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April 15, 1963



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ABSTRACT

Report E-1142 (Rev. 7) presents weight, center of gravity, and moment of inertia values for all components of the guidance and navigation equipment.

Power requirements of the guidance and navigation equipment upon the Primary +28 VDC Power Supply have also been included.

Only data pertaining to the command and service modules is, at present, included in this report.

E-1142 is prepared monthly and distributed on the 15th of each month.

Introduction

E-1142 (Rev. 7) is submitted in compliance with the documentation requirement of weight, center of gravity, and moment of inertia data for Apollo guidance and navigation equipment. At present, however, E-1142 pertains to only the command and service modules.

Power requirements, for Apollo guidance and navigation equipment, have been included to aid in the determination of spacecraft primary power.

Weights

All weight items are grouped according to their specific location within the spacecraft modules. Subsystem weights are reported to the component level and to the nearest tenth of a pound.

Given component weights are identified as calculated, measured, or estimated. These terms are defined by North American Aviation as follows:

Calculated weights (C) are weights based on detailed calculations made from final production drawings that will be used to build flyable equipment.

Measured weights (M) are the actual weights of equipment built to the production drawings.

Estimated weights (E) are rough calculations.

North American Aviation will provide and be responsible for coldplate weights which are not integral with guidance and navigation equipment.

Weight Status Reporting

Table 1 offers a comparison of present weight values with those listed

in the previous Weight and Balance Report, E-1142 (Rev. 6), March 15, 1963.

All weight changes are explained.

The "Spec. Weight" column contains "proposed MSC" weights, that is, goals set forth by MSC in a memo to MIT/IL dated December 5, 1962.

Centers of Gravity

The centers of gravity of each weight component or packaged assembly are determined with respect to the basic X, Y, Z axes of the command module which are shown in figure 1. Center of gravity values are given to the nearest tenth of an inch and are shown in table 2.

Moments of Inertia

Table 2 presents the moments of inertia, of each weight component or packaged assembly, determined about each of the component's axes which (1) run through the component's center of gravity and (2) are parallel to the basic X, Y, Z axes of the command module.

Accuracy

The accuracy of numerical values reported in this revision should not be considered to be within the tolerance implied by the significant figures quoted. Numerical values will approach the established tolerances as design and development phases approach completion.

Power Requirements

The electrical load of the guidance and navigation equipment, on the Primary + 28 VDC Power Supply, is shown in figure 2.

Explanation of Reported Weight Changes

IMU - Weight increase due to redesign of the 15x connector mount to provide access to the precision resolver alignment module.

IMU Control Panel - Due to recent design changes in the mounting facilities of the various displays and controls, the weight of the support hardware has been reduced.

Left Hand Turret - Additional definition of the modules and configuration changes have resulted in a re-evaluation of the Left Hand Turret weight.

Optical Shroud - Reduction in the inner skin thickness has resulted in a weight reduction of the Optical Shroud.

Spare Lamps (Three) - Spare item for Display and Control/Navigation not previously identified.

Spare Relay and Diode Module - Spare item for Display and Control/Navigation not previously identified.

Bellows Assy - Weight decrease due to shorter transition pieces and better weight evaluation.

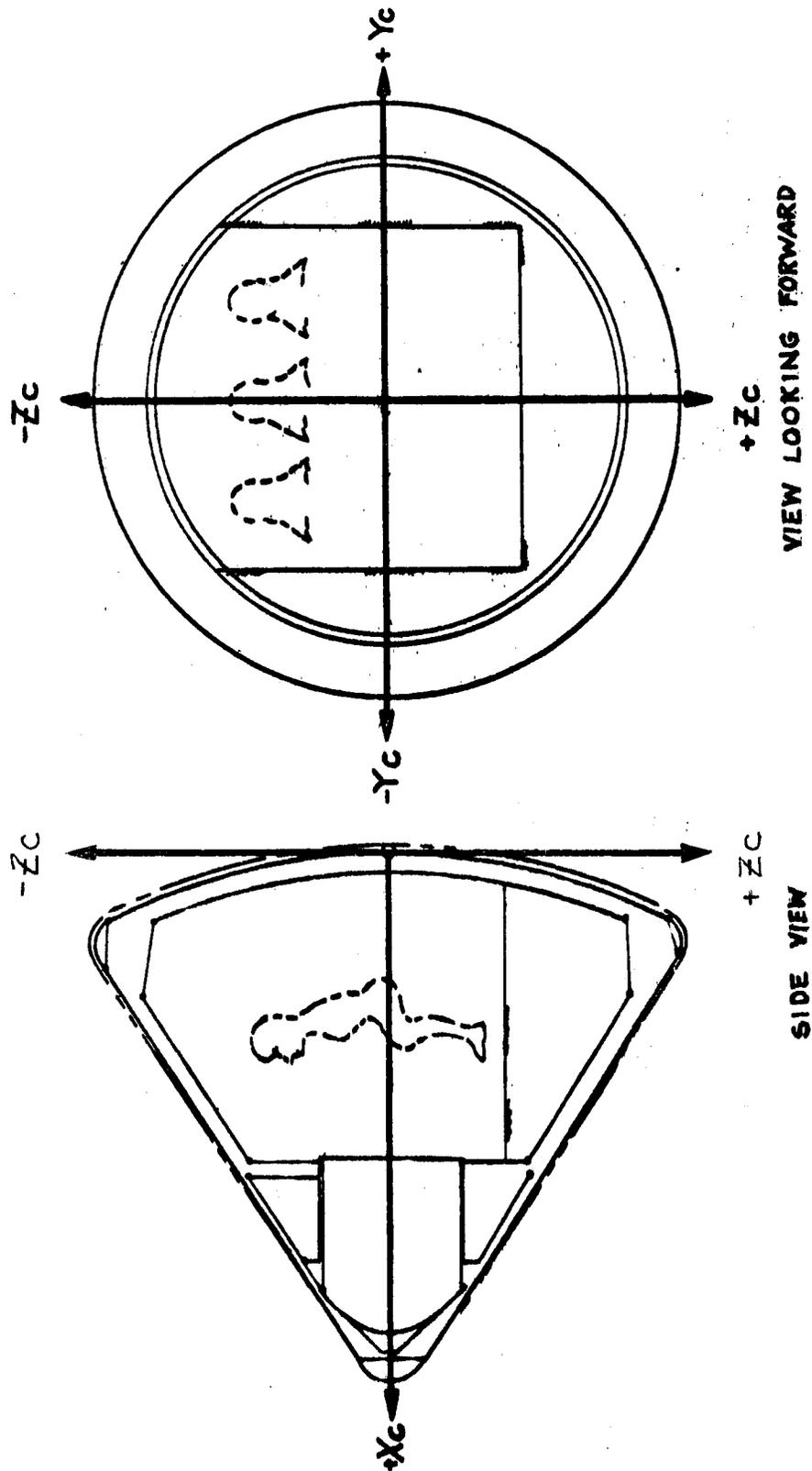


Figure 1. X, Y, Z axes of Command Module

APOLLO 6 & N WEIGHT & BALANCE REPORT

E-1142

Table 1. Current Weight Status

Item	Spec. 12/62 (a)	(b-a)	Status 3/63 (b)	(c-b)	Status 4/63 (c)
COMMAND MODULE					
<u>Lower Equipment Bay</u>					
CDU & Frame Assy	6.0	+10.5	16.5	0.0	16.5(E)
Optical Subsystem					
SXT	12.0	0.0	12.0	0.0	12.0(E)
SCT	9.0	0.0	9.0	0.0	9.0(E)
Opt Base & Gearing	14.0	+ 5.0	19.0	0.0	19.0(E)
Optical Eyepieces					
SXT			1.0	0.0	1.0(E)
SCT	2.0	+ 3.0	4.0	0.0	4.0(E)
IMU	50.0	+ 8.2	58.2	+0.3	58.5(E)
NVB & Shock Mounts	16.0	+ 8.0	24.0	0.0	24.0(E)
Bellows Assy	8.0	+ 3.0	11.0	-3.0	8.0(E)
Cabling	22.0	+ 3.0	25.0	0.0	25.0(E)
D & C Nav Station					
IMU Control Panel			6.3	-0.3	6.0(E)
Left Hand Turret	30.0	- 2.5	7.0	-3.8	3.2(E)
Optical Shroud			4.0	-0.2	3.8(E)
G&N Ind Cont Panel			10.2	0.0	10.2(E)
D & C/AGC	15.0	0.0	15.0	0.0	15.0(E)
M & DV (inc. 1 film)	5.0	+ 3.5	8.5	0.0	8.5(E)
AGC (no spares)	80.0	+13.0	93.0	0.0	93.0(E)
Spares Tray	- -	+4.0	4.0	0.0	4.0(E)
Stored Spares	- -	+11.0	11.0	0.0	11.0(E)
PSA	25.0	+24.7	49.7	0.0	49.7(E)
Stored Spares	- -	+2.5	2.5	0.0	2.5(E)
Signal Conditioning Tray	- -	+5.0	5.0	0.0	5.0(E)
		(Continued)			

APOLLO G & N WEIGHT & BALANCE REPORT

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Table 1. Current Weight Status (Cont'd)

Item	Spec. 12/62 (a)	(b-a)	Status 3/63 (b)	(c-b)	Status 4/63 (c)
Junction Box	8.0	+4.2	12.2	0.0	12.2(E)
<u>Main Panel Area</u>					
D&C/NAV	8.0	-8.0	0.0	---	---
D&C/AGC	5.0	+10.0	15.0	0.0	15.0(E)
<u>Loose Stored Items</u>					
Eye Relief Eyepieces	---	+3.0	3.0	0.0	3.0(E)
Film Cartridges (4)	---	+3.0	3.0	0.0	3.0(E)
AGC Loose Spares	} 20.0	+18.0	} 26.0	0.0	26.0(E)
PSA Loose Spares				9.0	9.0(E)
CDU Spare Gearbox				3.0	3.0(E)
Computer Self-Check Plug				1.0	1.0(E)
Horizon Photometer	---	+4.0	4.0	0.0	4.0(E)
Spare Lamps (3)	---	---	---	+0.2	0.2(E)
Spare Relay & Diode Module	---	---	---	+0.3	0.3(E)
SERVICE MODULE					
Radar					
(Transponder)	15.0	-5.0	10.0	0.0	10.0(E)
(Rendezvous Radar)	---	+30.0	30.0	0.0	30.0(E)
TOTAL	350.0	+162.1	512.1	-6.5	505.6

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Table 2. Center of Gravity and Moment of Inertia Data

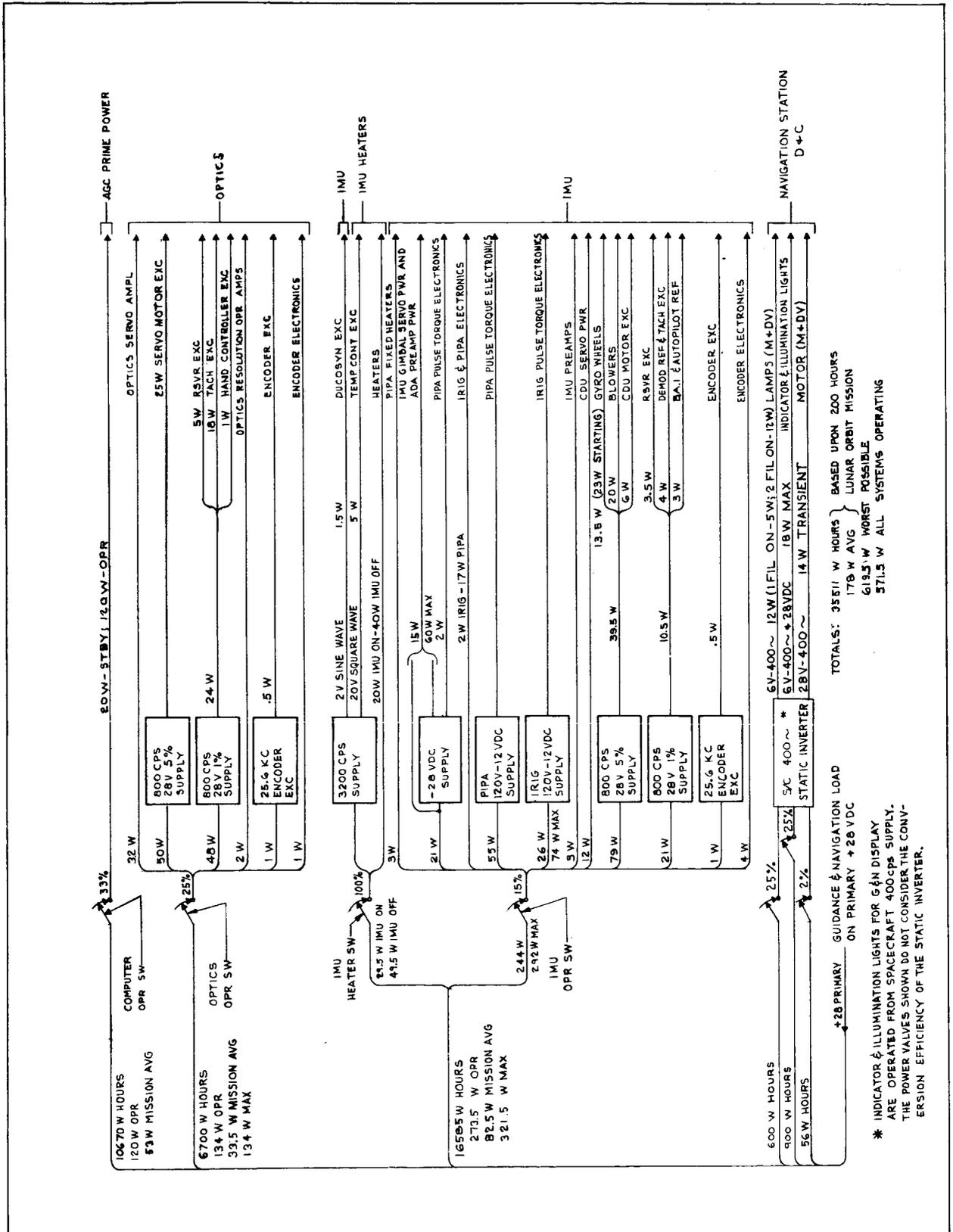
Item	Weight (lbs)	Center of Gravity (inches)			Moment of Inertia (lb-in ²)		
		X	Y	Z	I _{xx}	I _{yy}	I _{zz}
COMMAND MODULE							
Lower Equip. Bay	16.5(E)	63.5	-14.4	35.8	44	468	468
CDU & Frame Assy.	40.0(E)	69.0	1.7	32.3	-	-	-
Optical Subsystem	12.0(E)	-	-	-	-	-	-
SXT	9.0(E)	-	-	-	-	-	-
SCT	19.0(E)	-	-	-	-	-	-
Opt. Base & Gearing							
Optical Eyepieces							
SXT	1.0(E)	65.1	-3.5	26.2			
SCT	4.0(E)	65.1	4.5	26.2			
IMU	58.5(E)	56.6	0.0	41.7	1315	1315	1315
NVB & Shock Mounts	24.0(E)	60.6	0.0	44.0			
Bellows Assy	8.0(E)	71.5	-0.3	36.3			
Cabling	25.0(E)						
D & C/NAV Station	6.0(E)						
IMU Cont Panel	6.3(E)	73.0	-15.1	31.7			
Left Hand Turret	3.2(E)	49.5	-9.6	39.6			
Optical Shroud	3.8(E)	66.8	0.0	28.9			
G&N Ind. Control Pnl	10.2(E)	55.8	1.0	34.0			
D & C/AGC	15.0(E)						
M & DV (includes 1 film)	8.5(E)	73.5	-4.5	31.0			
AGC (no spares)	93.0(E)						
Spares Tray	4.0(E)						
Stored Spares	11.0(E)						
							(Continued)

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Table 2. Center of Gravity and Moment of Inertia Data (Cont'd)

Item	Weight (lbs)	Center of Gravity (inches)			Moment of Inertia (lb-in ²)		
		X	Y	Z	I _{xx}	I _{yy}	I _{zz}
COMMAND MODULE (cont'd)							
<u>Lower Equip. Bay (cont'd)</u>							
PSA	49.7(E)						
Stored Spares	2.5(E)						
Signal Conditioning Tray	5.0(E)						
Junction Box	12.2(E)						
<u>Main Panel Area</u>							
D & C/AGC	15.0(E)						
<u>Loose Stored Items</u>							
Eye Relief Eyepieces	3.0(E)						
Film Cartridges (4)	3.0(E)						
AGC Loose Spares	26.0(E)						
PSA Loose Spares	9.0(E)						
CDU Spare Gearbox	3.0(E)						
Computer Self Check Plug	1.0(E)						
Horizon Photometer	4.0(E)						
Spare Lamps (3)	0.2(E)						
Spare Relay & Diode Module	0.3(E)						
SERVICE MODULE							
Radar							
(Transponder)	10.0(E)						
(Rendezvous Radar)	30.0(E)						



Glossary

AGC:	Apollo Guidance Computer: complete computer, except display and keyboard. Includes: - all structural mounting rails, support for spare tray, AGC cable to front panel for spacecraft electrical interface, spare logic in four trays, and power supply.
BELLOWS ASSEMBLY:	Bellows Assembly: connection between Command Module and Optical Subsystem.
CABLING:	Cabling: intrasubassembly cabling in lower equipment bay. (Interequipment cabling from lower equipment bay to other assemblies is assumed a spacecraft responsibility.)
CDU & FRAME ASSEMBLY:	Coupling Display Units and frame assembly: five gear boxes and frame assembly, used as an angle data interface among the optics, IMU, AGC, and spacecraft autopilot.
D&C/AGC:	Display and Control, Computer: letter and number readout, keyboard, control, relays, and support structure.
D&C/NAV:	Display and Control, Navigation: consists of G & N Indicator Control Panel, IMU Control Panel, Left Hand Turret, and Optical Shroud. The above includes meters, switches, lights, etc. except as reported elsewhere. The weight does not include the clock group which is supplied by NAA.
G&N Ind Cont Panel:	G&N Indicator Control Panel: consists of the necessary switches, indicators, and controls for the navigation task not reported elsewhere. Includes optics hand controller, altitude impulse control, panel wiring, and supporting hardware.

IMU Cont Panel: IMU Control Panel: meters, switches, panel wiring and supporting hardware.

Left Hand Turret: Left Hand Turret: contains electronic modules.

Optical Shroud: Optical Shroud: includes protective cover.

EYE RELIEF EYEPIECES: Eye Relief Eyepieces: eyepieces to provide eye relief of at least 1.6 inches for closed visor operation.

FILM CARTRIDGES: Film Cartridges: film cartridges, including film, for Map and Data Viewer.

HORIZON PHOTOMETER: Horizon Photometer: an automatic, photometric, horizon detector device interchangeable with sextant eyepiece to provide capability for use of earth's illuminated limb as a navigation reference.

IMU: Inertial Measurement Unit: gimbal assembly, inertial components, data transducers, support structure, and internal cooling.

JUNCTION BOX: Junction Box: electrical interconnection center between subassemblies in lower equipment bay.

M&DV: Map and Data Viewer: film viewer for display of maps, charts, procedures, etc. Weight includes one film cartridge with film.

NVB & SHOCK MOUNTS: Navigation Base and Shock Mounts: rigid structure supporting the IMU and the Optical Subsystem with its associated hardware and supported by three shock mounts that attach the NVB to the spacecraft.

OPTICAL EYEPIECES: Optical Eyepieces: optical eyepieces for SXT and SCT.

OPTICAL SUBSYSTEM: Optical Subsystem: SXT, SCT, Optical Base and gearing, panel base, and associated hardware.

Optical Base & Gearing: Optical Base and Gearing: base for SCT and SXT with associated gearing.

SCT: Scanning Telescope: single line-of-sight, wide-field, two-degree-of-freedom telescope and its attached gearing.

SXT: Sextant: two line-of-sight, narrow field, two-degree-of-freedom sextant, including attached gearing and internal cooling.

PSA: Power Servo Assembly: IMU, SCT, and SXT servos, power supplies, CDU electronics, IMU backup mode electronics, and miscellaneous electronics.

Signal Conditioning Tray: Signal Conditioning Tray: tray in PSA to condition signals for telemetry and in-flight test equipment.

RADAR (Transponder and Rendezvous Radar) Radar (Transponder and Rendezvous Radar): electromagnetic ranging equipment, located in service module, for lunar orbit rendezvous.

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